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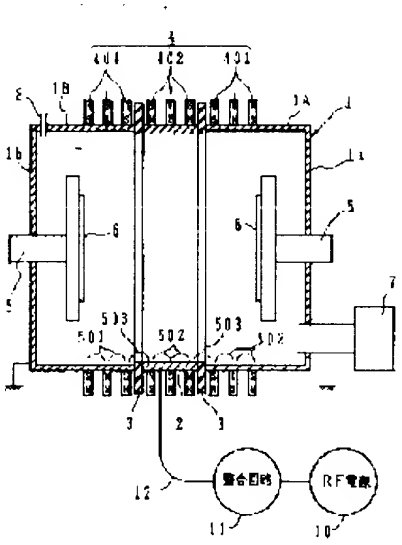
(54) SURFACE PROCESSOR

(57)Abstract:
PURPOSE: To simplify the structure of a surface processor and generate its plasma at a low pressure and reduce its energy for projecting ions on a substrate to be processed.
CONSTITUTION: In a surface processor, a vacuum container 1, an evacuation mechanism 7, a gas introducing mechanism, a cylindrical discharging electrode 2, electrode supply mechanisms 10, 11, 12 for supplying power to the discharging electrode 2, a magnetic circuit 4, and at least one substrate holding mechanism 5 are provided respectively. The magnetic circuit 4 comprises a plurality of annular permanent magnets 401, 402 which are arranged at spaces coaxially with the discharging electrode 2. Further, the respective annular permanent magnets 401, 402 are so magnetized radially that the polarities of their adjacent magnetic poles are opposite to each other. At least two adjacent annular permanent magnets to each other 402 are provided in the periphery of the discharging electrode 2, and the other permanent magnets 401, 401 are provided respectively in the peripheries of the front spaces of the substrate holding mechanisms 5, 5, and further, in the vicinities of the end parts of the magnetic circuit 4, the substrate-mounted surfaces of the substrate holding mechanisms 5, 5 are provided perpendicularly to the center axis of the discharging electrode 2.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] Especially this invention performs surface treatment of a substrate about surface treatment equipment using the plasma generated in electric discharge by a direct current, the RF, microwave, etc., and relates to the surface treatment equipment used as a dry etching system or plasma CVD equipment at a semiconductor-device manufacture process.
[0002]
[Description of the Prior Art] The high-frequency-discharge reactor used for the dry etching process which is one of the semiconductor-device manufacture processes as an example of conventional surface treatment equipment is explained. Dry etching technology is used in a circuit pattern formation distance indispensable to semiconductor-device manufacture. With dry etching technology, plasma-ize the mixed gas which made the gas containing a halogen the principal component by electric discharge, the various active species (for example, atom-like chlorine, an atom-like fluorine, a fluorine carbon compound, etc.) generated by this are made to react with the thin film on the front face of a substrate, and a thin film portion unnecessary as wiring is removed. Common practice is a method of causing electric discharge with the energy of RF power, and making inter-electrode [two] generating plasma, most by countering and preparing the plate-like electrode of two sheets into the vacuum housing which mixed gas is made to plasma-ize and by which the interior was decompressed, and supplying RF power to one electrode, and holding the electrode of another side to grounding potential. The equipment using this method is called parallel monotonous type electric discharge reactor, and is used in the latus field.
[0003] The magnetron type electric discharge reactor which raised the generation efficiency of plasma is known by adding the magnetic field generating means which makes a magnetic field within a vacuum housing as an advanced type of this parallel monotonous type electric discharge reactor.
[0004] The conventional example of typical composition of the parallel monotonous type electric discharge reactor used for drawing 7 by the dry etching system is shown, and this is outlined. The electrode for generating the electric discharge whose 72 71 served as the vacuum housing and served as the substrate maintenance mechanism, the electrode to which 73 counters an electrode 72, and 74 are substrates processed. An electrode 73 is held at grounding potential. The exhaust air mechanism in which 75 changes the interior of a vacuum housing 71 into a necessary reduced pressure state, and 76 are the gas introduction pipes for supplying reactant gas to the interior of a vacuum housing 71. RF power is supplied to an electrode 72 and the RF power supply 77 and a matching circuit 78 are attached as a mechanism for it. The insulator 79 which served as the vacuum lock is attached to an electrode 72.
[0005] The composition of the conventional magnetron type electric discharge reactor used as a dry etching system is shown in drawing 8 . The dry etching system which used the magnetic field together showed the so-called example of rotating-field-type equipment here, although many kinds of things were developed. In drawing 8 , the same thing as the element shown by drawing 7 attaches the same sign. the electrode to which 71 served as the vacuum housing and 72 served as the substrate maintenance mechanism and 73 -- for an exhaust air mechanism and 76, as for RF power supply and 78, a gas introduction pipe and 77 are [a counterelectrode and 74 a substrate and 75 a matching circuit and 79] insulators [namely,] Furthermore, the electromagnet equipment 80 which has a ring-like gestalt around [outside] a vacuum housing 71, and has magnetic pole arrangement structure special to the interior is installed. According to the electromagnet equipment 80 which has this special magnetic pole arrangement structure, a magnetic field vector (flux density B) 81 can be generated in the parallel direction to the processed side of the processed substrate 74 (reference : Journal of Nuclear Materials 200 (1993) pp 291-295). Moreover, generally rotating the direction of a magnetic field vector 81 on the processing side of a substrate 74 is also performed.
[0006] From the former, each of the electric discharge reactor of the two above-mentioned types is widely used as a dry etching system which carries out etching processing of the front face of a processed substrate, has sufficient performance about etching which performs micro processing with a line breadth of about 1 micrometer, and has an operating experience in many chip fabrication factories.
[0007]
[Problem(s) to be Solved by the Invention] The above-mentioned conventional dry etching system has the following problems.
[0008] The biggest reason for using dry etching in micro processing of a semiconductor-device manufacture process is in the point in which it is possible, anisotropic etching, i.e., etching which has a vertical section. However, in order to obtain a vertical section by dry etching about detailed structure 1 micrometer or less, you have to carry out incidence of the ion in plasma perpendicularly to a processed substrate. The easiest technique for improving rectilinear-propagation nature of the ion concerned

is making an electric discharge pressure low.
[0009] However, in the parallel monotonous type electric discharge reactor of drawing 7 , if an electric discharge pressure is made low too much, plasma density will fall and sufficient processing speed will not be obtained. If an electric discharge pressure is made low, it will become impossible moreover, to maintain the electric discharge itself. Therefore, there is a limitation in lowering an electric discharge pressure. Furthermore, by lowering an electric discharge pressure, the auto-bias voltage on cathode (electrode 74) becomes large, the incidence energy of the ion to the processed substrate 74 becomes large too much by this, and the danger of doing an injury to the front face of a processed substrate increases.
[0010] Incidence energy of plasma ion is made small and application of the magnetron type electric discharge reactor shown in drawing 8 is also widely tried in the viewpoint of preventing the injury on the front face of a substrate. in a magnetron form electric discharge reactor, it comes out, and this thing [making discharge voltage small] (1 - 10mTorr) that uses an external magnetic field together and performs generation of plasma can be performed, without enlarging auto-bias voltage on cathode, and irradiation energy of the ion to a substrate is made small as the result -- things can be carried out It has the advantage that it can moreover discharge also in a low electric discharge pressure as compared with an parallel monotonous type electric discharge reactor.
[0010] However, in the magnetron-discharge reactor, since the plasma generated was unevenly distributed depending on the distribution state of the magnetic field made, it had the problem that the homogeneity of plasma was bad.
[0011] In view of the above-mentioned problem, the purpose of this invention has easy structure, can generate plasma by the low voltage force, and is to offer the surface treatment equipment which can make small irradiation energy of the ion to a processed substrate.
[0012]
[Means for Solving the Problem] The exhaust air mechanism in which the surface treatment equipment concerning this invention changes the inside of a vacuum housing and this vacuum housing into a reduced pressure state, In order to make gas discharge and to generate plasma, the gas introduction mechanism which introduces the gas for electric discharge in a vacuum housing, and The electrode pattern of a cartridge, The electrode feeder style which supplies the power for plasma generating to this electrode pattern, and the magnetic circuit installed in the circumference of an electrode pattern, Have at least one substrate maintenance mechanism installed in a vacuum housing, and a magnetic circuit consists of two or more ring-like permanent magnets which were coaxial positions, set the interval and were put in order to the electrode pattern. Each ring-like permanent magnet is magnetized in the direction of a path so that the polarity of a ****** magnetic pole may become reverse mutually. The permanent magnet of two ****** is arranged around an electrode pattern at least among two or more ring-like permanent magnets. And other permanent magnets are arranged around the front space of a substrate support mechanism, and the field in which the processed substrate of a substrate maintenance mechanism is installed is perpendicularly arranged to the medial axis of an electrode pattern near the edge of a magnetic circuit.
[0013] In the aforementioned composition, it is prepared as a part of peripheral surface section of a vacuum housing, maintaining a vacuum lock, when an electrode pattern interposes an insulator among other portions of a vacuum housing preferably.
[0014] In each aforementioned composition, an electrode pattern has preferably the configuration of a cartridge where opened the crevice in the interior of a vacuum housing between the peripheral surface sections of a vacuum housing, and it has been arranged in same axle to a vacuum housing, and ends were opened wide.
[0015] In the aforementioned composition, the cartridge electrode which encloses an electrode pattern between a vacuum housing and an electrode pattern is preferably arranged in same axle, the length of the shaft orientations of a cartridge electrode is longer than the length of the shaft orientations of an electrode pattern, and a cartridge electrode is held at floating potential, and each ring-like permanent magnet of a magnetic circuit is arranged around a cartridge electrode. In addition, the structure where bias voltage can be impressed can be prepared in a cartridge electrode instead of holding to floating potential if needed.
[0016] In the aforementioned composition, the ring-like permanent magnet arranged preferably in the part equivalent to the circumference of an electrode pattern has been arranged to the space between an electrode pattern and a cartridge electrode.
[0017] In the aforementioned composition, it is characterized by having arranged other magnetic circuits which form an electrode pattern by the cylindrical part material which consists of a portion whose length of shaft orientations is two from which a path differs equally, and constitute it preferably using two or more ring-like permanent magnets around the small portion of the path of an electrode pattern.
[0018] In the aforementioned composition, preferably, an electrode pattern arranges in by turns the aforementioned portion from which a path differs, and is formed in the bellows configuration.
[0019] In the aforementioned composition, the electrode pattern was made into the inside-and-outside dual structure which consists of an internal electrode and an external electrode, and the ring-like permanent magnet has been arranged between an internal electrode and an external electrode.
[0020] In the aforementioned composition, sufficient crevice which electric discharge generates is formed between an external electrode and a cartridge electrode.
[0021] In the aforementioned composition, the magnetic pole of the opposite portion of the ring-like permanent magnet arranged at the electrode pattern and the ring-like permanent magnet arranged in the part corresponding to the electrode pattern in a cartridge electrode is like-pole nature.
[0022]
[Function] In this invention, homogeneous good high-density plasma may be easily generated by proposing the surface treatment equipment which can generate homogeneous good high-density plasma in the low voltage force, and using simultaneously also

for plasma production the magnetic field used for eye plasma ****** from the former. Moreover, application of a high-frequency-discharge mechanism is desirable considering line of magnetic force as generation of plasma, and composition for using simultaneous for shutting up.

[0023] In surface treatment equipment, the structure of the electrode which supplies the RF power for generating the electric discharge for plasma production is changed into tubed from plate-like [conventional], and a ring-like permanent magnet is arranged in the periphery enclosure of this electrode pattern. By this, it generates inside a tubed electrode pattern and plasma is diffused inside a vacuum housing. Moreover, densification of this plasma is conventionally carried out by the magnetic field by the ring-like permanent magnet. Furthermore, this high-density plasma is confined in the space in a vacuum housing with sufficient homogeneity by the line of magnetic force by the ring-like permanent magnet which was spread in the vacuum housing and has been arranged in addition to discharge space.

[0024] The line of magnetic force of the above-mentioned profit plasma used for shutting up is used also for generating of plasma, and high-density plasma is efficiently generated by the low voltage force, and the homogeneity of plasma is raised.

[0025]

[Example] Below, the example of this invention is explained based on an accompanying drawing.

[0026] Drawing 1 is drawing of longitudinal section showing the composition of the 1st example of the surface treatment equipment concerning this invention. In drawing 1 , 1 is a vacuum housing as the whole and the electrode pattern 2 of a cartridge (for example, cylindrical shape) is formed in the center section of the vacuum housing 1. The electrode pattern 2 is insulated from the both-sides portions (metal) 1A and 1B of a vacuum housing 1 with two ring-like insulators 3 arranged at the both sides. The vacuum housing 1 is formed as an airtight hermetically sealed enclosure of the electrode pattern 2 and the both-sides portions 1A and 1B of the above-mentioned cartridge, and the portion except the end-face sections 1a and 1b has a cartridge configuration like a cylinder. The portion which has this cartridge configuration is called "peripheral surface section" here. Moreover, the ring-like insulator 3 has the structure which carries out the vacuum lock of between each of the both-sides portions 1A and 1B of a vacuum housing 1, and electrode patterns 2. When the building envelope of a vacuum housing 1 performs surface treatment, the gas for electric discharge which was held and was introduced into the necessary vacua (reduced pressure state) is made to discharge, and required plasma is generated. Moreover, the both-sides portions 1A and 1B of a vacuum housing 1 are held at grounding potential.

[0027] In a vacuum housing 1, two substrate maintenance mechanisms 5 are countered and installed in the substrate maintenance side. The substrate maintenance mechanism 5 is attached in the end-face sections 1a and 1b of the both sides of a vacuum housing 1. Surface treatment is performed to the processed substrate 6 carried on each of two substrate maintenance mechanisms 5.

[0028] The magnetic circuit 4 which consists of a ring-like permanent magnet is installed in the circumference of an outside of the peripheral surface section of the cylindrical shape containing the electrode pattern 2 in a vacuum housing 1. A magnetic circuit 4 consists of two or more ring-like permanent magnets 401,402 put in order and installed at the suitable interval. The ring-like permanent magnet 401,402 is arranged to the peripheral surface section containing an electrode pattern 2 in a same axle-position. At least two permanent magnets 401 are arranged around the both-sides portions 1A and 1B of a vacuum housing 1, and at least two permanent magnets 402 are arranged around an electrode pattern 2. The both-sides portions 1A and 1B of a vacuum housing 1 have the front space of the substrate 6 of each substrate maintenance mechanism 5 inside, respectively, and the ring-like permanent magnet 401 is installed so that the front space may be surrounded. With the composition of the magnetic circuit 4 by two or more permanent magnets 401,402, as shown in drawing 1 , the direction of a path is magnetized, and the ring-like permanent magnet is magnetized so that arrangement of a magnetic pole may become reverse mutually with a ****** permanent magnet.

[0029] The field in which the processed substrate 6 of the above-mentioned substrate maintenance mechanism 5 is installed is perpendicularly arranged to the medial axis of an electrode pattern 2 near the edge of a magnetic circuit 4.

[0030] The exhaust air mechanism 7 is formed in end-face section 1a of a vacuum housing 1, and the gas which exists in the building envelope is exhausted. Moreover, the predetermined gas of a predetermined flow rate is introduced into a vacuum housing 1 by the gas introduction pipe 8 and the gas introduction mechanism (not shown). By adjusting the gas introduction flow rate by the exhaust speed of the exhaust air mechanism 7, and the gas introduction mechanism, the pressure in a vacuum housing 1 can be set as a predetermined value.

[0031] An electric power supply mechanism is attached to an electrode pattern 2, and required power is supplied. An electric power supply mechanism is constituted including the RF (RF) power supply 10 and a matching circuit 11, adjusts the RF power generated by RF generator 10 by the matching circuit 11, and supplies it to an electrode 2 with a feeder 12.

[0032] In addition, he shall understand an electric power supply mechanism in a wide sense, and it shall include the electric power supply mechanism by a direct current, the RF, and microwave. However, this example explains the 13.56MHz application specified to be a RF, especially industrial use frequency.

[0033] With reference to drawing 1 and drawing 2 , fundamental operation of surface treatment equipment based on the above-mentioned composition is explained. Drawing 2 is drawing showing the configuration of a magnetic field by the magnetic circuit 4, and the generation state of the plasma under the influence, simplifies and shows a vacuum housing 1 and is omitting the insulator 3 and the substrate maintenance mechanism 5 in this drawing.

[0034] The interior of a vacuum housing 1 is first exhausted according to the exhaust air mechanism 7, and it changes into a necessary reduced pressure state, and it introduces in a vacuum housing 1 so that it may become a predetermined pressure about predetermined gas according to the gas introduction pipe 6 and a gas introduction mechanism after that. This predetermined

pressure is set up so that it may become each optimum value by the type of gas, magnetic field strength, etc.
[0035] Next, the RF power generated by RF generator 10 is supplied to an electrode pattern 2 through a matching circuit 11. Consequently, electric discharge by the RF occurs to the inside space of the electrode pattern 2 of a cylindrical shape, and plasma is generated. The generating state of the plasma at this time is decided depending on the composition of a magnetic circuit 4.
[0036] As shown in drawing 1 and drawing 2 , in this example, the ring-like permanent magnet which constitutes a magnetic circuit 4 is divided and provided in two groups (a permanent magnet 401 and permanent magnet 402) with the property of the operation. The operation by the permanent magnet 401 is that the line of magnetic force 501 made with a permanent magnet 401 crosses only the vessel wall of the both-sides portions 1A and 1B of a vacuum housing 1. The operation by the permanent magnet 402 is that the line of magnetic force 502 made with a permanent magnet 402 crosses an electrode pattern 2, and spreads in the building envelope. The line of magnetic force 503 generated in the boundary section of a permanent magnet 401 and a permanent magnet 402 crosses the vessel wall of the both-sides portions 1A and 1B of a vacuum housing 1, and the both sides of an electrode pattern 2.
[0037] In the vacuum housing 1 for surface treatment equipped with the magnetic circuit 4 which produces the above-mentioned operation, the plasma generated by the building envelope using the electrode pattern 2 has the following features. In order to generate plasma, when RF power is supplied to an electrode pattern 2, the electric field (electric field as the average) by high-frequency voltage exist in the front face of an electrode 2, it collides with the gas molecule (atom) by which the electron accelerated by this was introduced in the vacuum housing 1, and it is maintained, while high-density plasma is generated locally and is especially spread in a vacuum housing 1 by ionizing this. When plasma occurs, movement of the electron in plasma is determined by the magnetic field made from a magnetic circuit 4. In this example, the high-density plasma 505 is especially generated by the part shown in drawing 2 based on an interaction with a magnetic field 502. Generation / maintenance mechanism of the plasma in this example is fundamentally [as the conventional magnetron form electric discharge reactor] the same. However, when it states in more detail, by generation / maintenance mechanism of the plasma of this example, it has the following features by composition of the ring-like permanent magnet 402 installed in the electrode pattern 2 and its periphery enclosure for plasma generating.
[0038] The voltage drop section (potential difference) is between the inside front face of the electrode pattern 2 which carried out the cylindrical shape, and the plasma generated by the building envelope, and direct-current electric field (electrostatic field) exist there. The movement direction of the electron in plasma is determined by the component which intersects perpendicularly with the electric field concerned among this electric field and the magnetic field 502 generated with the permanent magnet 402. Specifically, the electron moved in the direction of the outer product of the vector of electric field, and the vector of a magnetic field (method of the inside of the direction of a path), it exercised for the hoop direction along with the wall of an electrode pattern 2 based on the operation of electric field and a magnetic field, and the moving trucking has closed. Thus, when the electron-transfer path in a plasma generating field has closed, dissipation of the electron in a plasma generating field is suppressed, and high-density plasma can be generated easily and maintained locally. The feature of the high-density plasma generated by composition of this example is to form a ring-like field and generate [approach the inside front face of an electrode pattern 2,] high-density plasma, as shown in 505 of drawing 2 . In order to generate plasma in a ring-like field, it is required like the above-mentioned for two or more ring-like permanent magnets 402 to change arrangement of a magnetic pole by turns around the cylindrical shape-like electrode pattern 2, to arrange them, and for the line of magnetic force 502 made by them to intersect the inside front face of an electrode pattern 2, and to cross the front face concerned.
[0039] In the plasma generated to the inside space of an electrode pattern 2 as mentioned above, the ion which exists in it and the activated gas molecule, or an atom is diffused inside [whole] a vacuum housing 1, reacts with the thin film formed in the front face of the processed substrate 6, and removes this. At this time, the magnetic field 501 generated with a permanent magnet 401 has the operation which loss by the collision with the internal surface of the both-sides portions 1A and 1B of the vacuum housing 1 of the charged particle in plasma is decreased, and keeps the density of plasma high, and makes good homogeneity of plasma density [near the front face of the processed substrate 6].
[0040] Since the vacuum housing both-sides portions 1A and 1B and an electrode pattern 2 are unified in the above-mentioned example and the vacuum housing 1 is constituted, it becomes unnecessary to arrange an electrode pattern in a vacuum housing 1. moreover, since a magnetic circuit 4 can be installed into the atmosphere, it is easy to establish the structure for cooling a magnetic circuit 4, and maintenance control is easy -- etc. -- it has an advantage on structure
[0041] The ion which the feature of this invention makes generate the high-density plasma 505 which exists in the field of a ring-like gestalt using a magnetic field 502 in the above-mentioned example so that clearly, and is generated with this high-density plasma 505 and the activated gas molecule, or an atom is diffused efficiently and uniformly by still more nearly another magnetic field 501, and it is in the point which made surface treatment of the processed substrate 6 possible by this.
[0042] Next, the 2nd example of this invention is explained with reference to drawing 3 . In drawing 2 , the same sign is substantially given to the same element with the element explained by drawing 1 . the feature of this example -- an electrode pattern -- a vacuum housing -- another -- preparing -- the electrode pattern of this cylindrical shape -- the interior of a vacuum housing 1 -- it is -- a coaxial position -- and it is in the point installed in the mid gear of shaft orientations 2 is the electrode pattern of a cylindrical shape and is made from the path smaller than the path of a vacuum housing 1. Illustration of the member which supports an electrode 2 is omitted. With the feeder 12 wired through the small pipe-like insulator 13 which served as the vacuum-lock member, RF power is supplied to an electrode pattern 2, and it generates plasma with this RF power. It is necessary to make the crevice 14 between a vacuum housing 1 and an electrode pattern 2 into an interval small to the grade into which

electric discharge does not enter between them. Although the size of this interval changes with the kinds and pressures of gas which discharge, generally several mm (mm) grade is desirable. Moreover, a vacuum housing 1 is held at grounding potential.
[0043] In this example, the structure of the connection of the ring-like insulator 3 needed in the 1st example, and the electrode 2 and the vacuum housing both-sides portions 1A and 1B becomes unnecessary, and it has the advantage that an equipment configuration is simplified at this point. Moreover, since an electrode pattern 2 and a vacuum housing 1 are made as another member, the path of the peripheral surface section can make the large vacuum housing 1 easily. About other equipment configurations and the magnetization direction of a permanent magnet 401,402, it is completely the same as the 1st example. Moreover, also in this example, the mechanism for generation and maintenance of plasma is completely the same as what was explained in the 1st example.
[0044] In the above-mentioned 1st and the 2nd example, the internal surface of a vacuum housing 1 has the property that the spatter of the ion in plasma is easy to be carried out. When giving the bias of a direct current or an alternating current to the substrate maintenance mechanism 5 and processing the front face of the processed substrate 6 especially, the spatter of the wall of a vacuum housing 1 is carried out, or fault, like electric discharge becomes unstable arises. This cause is because the vacuum housing in grounding potential is used as an electrode in each above-mentioned example. That is, it is for sputtering which originates in acceleration of the ion by this by plasma potential's changing according to the bias of the substrate maintenance mechanism 5, and the potential difference between plasma potential and grounding potential, i.e., the direct-current electric field in the sheath made in the internal surface of a vacuum housing 1, becoming large to tend to break out. Furthermore, if said potential difference becomes very large, local arc discharge may occur and the state of plasma may become unstable. The following examples are proposed in order to cancel this fault.
[0045] The 3rd example of this invention is explained with reference to drawing 4 . The feature of this example is in the point of having installed the 2nd cylinder-like electrode 9 (it being hereafter described as the cylinder-like electrode 9) between the electrode pattern 2 and the vacuum housing 1, in the composition of the 2nd above-mentioned example. The cylinder-like electrode 9 is an anode plate, and it is formed so that the length of the shaft orientations may become long rather than an electrode pattern 2. Moreover, it is fixed to a vacuum housing 1 through an insulator (not shown), and the cylinder-like electrode 9 is made to float electrically preferably. Moreover, the structure for bias impression which contains bias power supply 19 in the cylinder-like electrode 9 may be established if needed, and arbitrary bias (grounding potential is also included) may be given by bias power supply 19. A magnetic circuit 4 is installed between the voltage cylinder-like electrode 9 and a vacuum housing 1. The structure of a magnetic circuit 4 is the same as the case of the 1st and 2nd examples.
[0046] RF power is supplied by the electrode pattern 2 with the same insulator 13 as the 2nd example, and the feeder 12 wired through the same small insulator 16 which served as the vacuum-lock member prepared in the cylinder-like electrode 9, and it is made to generate plasma with this RF power. An insulator 16 can extend an insulator 13 and can also form it as the same object. The mechanism for generation and maintenance of the plasma in this example is the same as the mechanism explained in each above-mentioned example. The crevice 15 between an electrode pattern 2 and the cylinder-like electrode 9 is made small to the grade into which electric discharge does not enter between them, and is almost the same as the aforementioned crevice 14 dimensionally. Moreover, between the cylinder-like electrode 9 and a vacuum housing 1, sufficient crevice for a magnetic circuit 4 to install is formed. In addition, when it is difficult to prepare sufficient crevice to install a magnetic circuit 4 between a vacuum housing 1 and the cylinder-like electrode 9, a magnetic circuit 4 can also be installed in the outside of a vacuum housing 1.
[0047] Since the potential of the cylinder-like electrode 9 changes according to plasma potential when the bias of a direct current or an alternating current is given to the substrate maintenance mechanism 5 by making the cylinder-like electrode 9 float electrically according to the 3rd example, the potential difference with plasma potential will be kept small, and the fault in the 2nd example is canceled. Moreover, when the substrate maintenance mechanism 5 cannot apply the structure top bias voltage easily, the energy of the ion which carries out incidence to the processed substrate 6 can be controlled by giving bias to the cylinder-like electrode 9. Furthermore, in electric discharge by the RF, the space potential of about six processed substrate plasma vibrates by the RF, the energy width of face of the ion which carries out incidence to the processed substrate 6 spreads, and it may have a bad influence on a micro-processing process. At this time, a vacuum housing 1 and the cylinder-like electrode 9 can be connected through a capacitor instead of the bias power supply in a view 3, vibration by the RF about the potential of the cylinder-like electrode 9 can be erased by this, and vibration of the space potential of plasma can be suppressed. The capacity of a capacitor should just fully have a low impedance to the RF of frequency used for electric discharge.
[0048] Next, the 4th example of this invention is explained with reference to drawing 5 . In this example, it has the structure which continued alternately with plurality and formed the large portion (major-diameter section) 201 of a path, and the small portion (minor diameter section) 202 of a path in an electrode pattern 2 in the composition of the 3rd above-mentioned example. An electrode pattern 2 has a configuration similar to the bellows configuration by which the minor diameter section and the major-diameter section are repeatedly formed in shaft orientations. Moreover, the permanent magnet 402 for performing plasma production among magnetic circuits 4 is installed in the space between the small portion 202 of the path of an electrode pattern 2, and the cylinder-like electrode 9. It is necessary to make the crevice 17 between the large portion 201 of the path of an electrode pattern 2, and the cylinder-like electrode 9 small to the grade into which electric discharge does not enter between them, and it is almost the same as a crevice 14. [of the size] Moreover, although it is desirable to prepare the crevice where between a permanent magnet 402 and the cylinder-like electrodes 9 is of the same grade, when the quality of the materials of a permanent magnet 402 are insulators, such as a ferrite, they do not necessarily need a crevice. Other equipment configurations and the magnetization direction of a permanent magnet are completely the same as the case of the 3rd example.

[0049] Plasma is generated to the inside space of the large portion 201 of the path of an electrode pattern 2. In generation of the plasma by this example, densification of plasma has been further realized by using together the plasma production and the maintenance mechanism by the so-called hollow cathode effect (operation which generates high-density plasma when an electron moves reciprocately between the cathode installed by approaching) with generating of the high-density plasma by the magnetron discharge explained in the 1st example, and its maintenance.
[0050] The 5th example of this invention is explained with reference to drawing 6 . The feature of this example is in the structure of the cylinder-like permanent magnet 402 which constitutes the magnetic circuit an electrode pattern 2 and for plasma generating. An electrode pattern 2 arranges the portion (henceforth an internal electrode) 203 with the equal and length of shaft orientations, and a small path, and the large portion (henceforth an external electrode) 204 in piles in and abroad, and it connects electrically and it consists of this examples. Although it needed to be made small to the grade into which electric discharge does not enter between them in each above-mentioned example, the crevice 18 between the external electrode 204 and an electrode pattern 2 is formed as a to some extent big crevice, in order to use this crevice 18 as space for plasma generating in this example. Although the size of this crevice 18 changes with pressures of the discharging gas, generally several cm (cm) grade is desirable.
[0051] Moreover, two or more ring-like permanent magnets 403 for generating plasma are arranged to the space between the internal electrode 203 of an electrode pattern 2, and the external electrode 204. The magnetization direction of the ring-like permanent magnet 403 is performed like the case of a permanent magnet 401. Moreover, the position of a permanent magnet 403 is arranged so that the outside magnetic pole may face the inside magnetic pole of the ring-like permanent magnet 402, and further, the sense of a magnetic pole is installed so that the magnetic pole which the ring-like permanent magnet 402 and the ring-like permanent magnet 403 face may turn into the same pole. Other equipment configurations and the magnetization direction of the other permanent magnets 401,402 are completely the same as the 1st example.
[0052] Moreover, the cylinder-like electrode 9 is made into floating potential also in this example, and that of the fundamental principle of operation about an electrode 9 is the same as that of the case of the 4th example.
[0053] In this example, plasma is generated in two places, the inside space of the internal electrode 203 of an electrode pattern 2, and the crevice 18 between the external electrode 204 of an electrode pattern 2, and the cylinder-like electrode 9. The mechanism for generation and maintenance of the plasma generated to the inside space of an internal electrode 203 is completely the same as the mechanism explained in the 1st example. Moreover, about generation of the plasma in a crevice 18, it has the structure which enabled realization of the densification of the further plasma according to the mechanism of the plasma production and maintenance by combined use of the magnetron discharge explained in the 2nd example, and the hollow cathode effect.
[0054] Although it had two substrate maintenance mechanisms according to symmetrical physical relationship in the vacuum housing in each aforementioned example, it is also good to establish one substrate maintenance mechanism.
[0055]
[Effect of the Invention] A device is written in the configuration of an electrode pattern at the above explanation so that a part of line of magnetic force which was conventionally used for the loss preventions of plasma in the surface treatment equipment by the magnetron discharge using the RF etc. according to [so that clearly] this invention can be used also for the plasma production by the magnetron discharge, high-density plasma is generated efficiently, and the homogeneity of surface treatment can be kept good to a processed substrate. The effect will become remarkable if this invention is applied to a dry etching system, a CVD system, etc. which are plasma treatment equipment of which various kinds of high-speed and uniform large area processings are required.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] A device is written in the configuration of an electrode pattern at the above explanation so that a part of line of magnetic force which was conventionally used for the loss preventions of plasma in the surface treatment equipment by the magnetron discharge using the RF etc. according to [so that clearly] this invention can be used also for the plasma production by the magnetron discharge, high-density plasma is generated efficiently, and the homogeneity of surface treatment can be kept good to a processed substrate. The effect will become remarkable if this invention is applied to a dry etching system, a CVD system, etc. which are plasma treatment equipment of which various kinds of high-speed and uniform large area processings are required.

[Translation done.]

CLAIMS

[Claim(s)]

[Claim 1] Vacuum housing. The exhaust air mechanism which changes the inside of this vacuum housing into a reduced pressure state. The gas introduction mechanism which introduces the gas for electric discharge in the aforementioned vacuum housing. It is the electrode pattern of a cartridge in order to make the aforementioned gas discharge and to generate plasma. The electrode feeder style which supplies the power for plasma generating to this electrode pattern, the magnetic circuit installed in the circumference of the aforementioned electrode pattern, and at least one substrate maintenance mechanism installed in the aforementioned vacuum housing. Are surface treatment equipment equipped with the above, and the aforementioned magnetic circuit consists of two or more ring-like permanent magnets which were coaxial positions, set the interval and were put in order to the aforementioned electrode pattern. Each aforementioned ring-like permanent magnet is magnetized in the direction of a path so that the polarity of a ****** magnetic pole may become reverse mutually. The aforementioned permanent magnet of two ****** is arranged around the aforementioned electrode pattern at least among two or more aforementioned ring-like permanent magnets. And the other aforementioned permanent magnets are arranged around the front space of the aforementioned substrate support mechanism, and the field in which the processed substrate of the aforementioned substrate maintenance mechanism is installed is characterized by what is perpendicularly arranged to the medial axis of the aforementioned electrode pattern near the edge of the aforementioned magnetic circuit.

[Claim 2] Surface treatment equipment characterized by setting to surface treatment equipment according to claim 1, and being prepared as a part of peripheral surface section of the aforementioned vacuum housing, the aforementioned electrode pattern maintaining a vacuum lock by interposing an insulator among other portions of the aforementioned vacuum housing.

[Claim 3] It is surface treatment equipment characterized by having the configuration of a cartridge where the aforementioned electrode pattern opened the crevice in the interior of the aforementioned vacuum housing between the peripheral surface sections of the aforementioned vacuum housing in surface treatment equipment according to claim 1, and it has been arranged in same axle to the aforementioned vacuum housing, and ends were opened wide.

[Claim 4] It is surface treatment equipment characterized by arranging the cartridge electrode which encloses the aforementioned electrode pattern between the aforementioned vacuum housing and the aforementioned electrode pattern in same axle in surface treatment equipment according to claim 3, the length of the shaft orientations of the aforementioned cartridge electrode being longer than the length of the shaft orientations of the aforementioned electrode pattern, and holding the aforementioned cartridge electrode at floating potential, and arranging each ring-like permanent magnet of the aforementioned magnetic circuit around the aforementioned cartridge electrode.

[Claim 5] Surface treatment equipment characterized by having arranged the aforementioned ring-like permanent magnet arranged in surface treatment equipment according to claim 4 in the part equivalent to the circumference of the aforementioned electrode pattern to the space between the aforementioned electrode pattern and the aforementioned cartridge electrode.

[Claim 6] Surface treatment equipment characterized by having arranged other magnetic circuits which form the aforementioned electrode pattern by the cylindrical part material which the length of shaft orientations becomes from the portion which is two from which a path differs equally, and constitute it in surface treatment equipment according to claim 4 or 5 using two or more ring-like permanent magnets around the small portion of the path of the aforementioned electrode pattern.

[Claim 7] The aforementioned electrode pattern is surface treatment equipment characterized by arranging in by turns the aforementioned portion from which a path differs in surface treatment equipment according to claim 6, and being formed in a bellows configuration.

[Claim 8] Surface treatment equipment which makes the aforementioned electrode pattern the inside-and-outside dual structure which consists of an internal electrode and an external electrode in surface treatment equipment according to claim 4 or 5, and is characterized by having arranged the ring-like permanent magnet between the aforementioned internal electrode and the aforementioned external electrode.

[Claim 9] Surface treatment equipment characterized by forming sufficient crevice which electric discharge generates between the aforementioned external electrode and the aforementioned cartridge electrode in surface treatment equipment according to claim 8.

[Claim 10] Surface treatment equipment characterized by the magnetic pole of the opposite portion of the aforementioned ring-like permanent magnet arranged at the aforementioned electrode pattern and the aforementioned ring-like permanent magnet arranged in the part corresponding to the aforementioned electrode pattern in the aforementioned cartridge electrode being a like pole in surface treatment equipment according to claim 8 or 9.

[Translation done.]